United States
Department of the Interior
Geological Survey

# Letter regarding an investigation to determine the possibilities of an additional water supply for the Army Air Force Flexible Gunnery School near Kingman, Arizona

By

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

5373 East Second Street
Long Beach, California

April 19, 1943

The District Engineer
U. S. Engineer Office
751 South Figueroa St.
Los Angeles, California

Dear Sir:

In accordance with a telephone request from Mr. C. F. Hostrup of your office, the writers, S. F. Turner and J. F. Poland of the Geological Survey, accompanied by Mr. Hostrup, have made a brief 3-day reconnaissance investigation to determine the possibilities for additional water supply for the A. A. F. Flexible Gunnery School which is located about 8 miles northeast of Kingman on the alluvial plain of Hualpai Valley in Mohave County, Arizona. The field study was made from April 13 to 15, 1943.

Present system and need for additional supply. The present supply of water for the Post is pumped from two wells located in Johnson Wash in the Cerbat Mountains, about six miles northwest of the town of Kingman and about 8 miles west of the Post. (See accompanying sketch map.) Post well 1, also called "Upper Well", was the second well drilled by the Kingman Water Company and thus is carried as well 2 on their records. Post well 2, "Lower Well", was the first well drilled and is carried as well 1 by the Kingman Water Company. The Post well numbers will be used in referring to these wells in this report. Post well 1,

located about 0.9 mile northwest of well 2, is 286 feet deep, with 12-inch casing to 20 feet and 8-inch uncased hole from 20 to 286 feet below land surface. Post well 2 is 229 feet deep with 12-inch casing to 20 feet and 12-inch uncased hole from 20 to 229 feet below land surface.

These wells were drilled in May 1941 but were not put into operation until September 1942. From that time to April 1943, about 30,000,000 gallons of water have been pumped from the two wells. The current Post demand is reported to be 550,000 gallons per day; the current capacity of Post well 2 is 250 gallons a minute. This well has been pumped daily since September 1942. Post well 1 failed temporarily in March and early April 1943, apparently because of falling water level but after the pump column had been lengthened it was put back on production on April 15. Because of the failure of well 1, well 2 had been pumped about 16 hours each day to supply Post demand. The production table appended to this report shows that for well 1, the static level has declined 28 feet and the specific capacity has decreased about 50 percent, and for well 2 the static level has declined about 39 feet and the specific capacity has decreased about 80 percent since pumping commenced in September, 1942.

The performance record of the two wells indicates that there is critical need for a supplementary water supply for the Post.

General geology and hydrology. The Cerbat Mountains to the north of Kingman and the Hualpai Mountains to the south consist chiefly of granitic and metamorphic rocks of Pre-Cambrian Age. During Tertiary time, a blanket of volcanic flows and ash beds was deposited on top of the older rocks. These volcanic deposits have been deeply

dissected and eroded away from most of the Cerbat Mountains, but a mass of volcanic rocks about 12 miles long and 6 miles wide blankets the saddle between the Cerbat and Hualpai Mountains. The town of Kingman lies about at the center of the saddle, and highway US 66 bisects the area of volcanic rocks.

The volcanic deposits, ranging from 500 to 1,000 feet in thickness, comprise rhyolitic, andesitic, and basaltic lava flows interbedded with tuff and ash beds. They have a regional southeasterly dip of about 5°, attaining probable maximum thickness of 1,000 feet about 1 mile north of Kingman. About 600 to 700 feet of the volcanic series are exposed on the walls and in the bottom of Johnson Wash north of Kingman; about 6 miles north of the town and 1,200 feet upstream (northwest) from well 1 the contact between the volcanics and the old Pre-Cambrian rocks can be seen in the wash. The irregular shape of the contact visible on the valley sides at this location suggests that the volcanics were deposited on a rather rugged surface. If so, hills of Pre-Cambrian rock may be buried under the lava flows and the thickness of the volcanic series may vary considerably along the strike of the beds.

The more basic lava flows in the volcanic series have some initial permeability because of their vesicular and scoriaceous character; columnar jointing is also prominent. The series also has been cut by faulting, shear zones, and multiple joints. A part of this shearing activity has served to increase the permeability of the more massive members. However, development of gouge, cementation, and recrystallization has filled at least some of the more prominent faults and shear zones, and these cemented zones now act as ground-water dams. Such

dams are here approximately vertical and probably serve as a barrier to horizontal water movement through essentially the entire thickness of volcanics where they occur. On the other hand, the impervious ash and tuff members are about horizontal in position and act to restrain downward movement of water through the pervious lava beds interbedded with them, except where fracturing has opened passages. However, the high initial specific capacity of Post wells 1 and 2, drilled in the volcanics about 0.25 and 1.1 miles southeast, respectively, from the Pre-Cambrian contact, suggests that locally the volcanics are highly permeable.

The major structural unit controlling water movement in the lavas is the Beale Spring fault. This fault trends about N. 70° W. and dips about 70° north. It passes through the north side of Kingman and can be traced for at least 4 miles to the west, passing immediately south of Beale Spring. This spring, about 2 miles northwest of Kingman, marks the site of old Fort Beale. The south face or footwall of the fault is indurated and recrystallized, apparently by heat generated at the time of faulting, and now stands as a prominent "dike". At Beale Spring, the fault is offset horizontally about 300 feet, probably by a shear zone trending about N. 20° E. The fault zone acts as an effective barrier to southward movement of the ground water in the volcanics; everywhere that a topographic valley or wash cuts south across the fault plane to form a depression in the barrier, water can be seen seeping over the edge of the fault "dike". All of the springs occurring along this feature are small except for Beale Spring which probably is controlled by the composite barrier action of the fault "dike" and the cross-cutting shear zone mentioned above. According to the Kingman Water Company, Beale

Spring currently furnishes about 50 gallons a minute to the town of Kingman by gravity flow through a pipe line. On April 13, 1943, the overflow at the spring was about 40 gallons per minute, suggesting a total flow of about 90 gallons a minute.

Grapevine Spring lies about half a mile northwest of and about 180 feet above Beale Spring, on the east edge of a small hill. On the south side of the same hill and at about the same altitude, other smaller springs occur, suggesting concentration of the water on top of a buried erosion surface and escape along the lowest exposed segment. The total flow of these springs on April 13, 1943 was about 35 gallons a minute. This flow is not used, but some of it probably contributes to Beale Spring. The Kingman Water Company has drilled a 250-foot well about 300 feet downslope from Grapevine Spring. It is reported that water was struck at 80 feet and rose to 15 feet below land surface. During an 8-hour test, the well reportedly produced 300 gallons a minute. It is now capped as an emergency standby.

In Johnson Wash there are several spring developments. The general location of these springs is shown on the accompanying sketch map which is based in part on U. S. Grazing Service maps.

Lange Spring, about 1-1/2 miles north of Kingman, rises immediately upstream from an impervious rhyolytic tuff bed exposed in the creek bottom. The flow of this spring in the creek bottom was about 25 gallons a minute on April 15, 1943; the Kingman Water Company reported that another 20 to 25 gallons a minute is currently diverted into the Kingman water system through a collection tunnel in the east bank of the wash. Also, the Water Company reports that a well located about 20 feet east of the collection tunnel was drilled to a depth of 300 feet in

June 1942 and made only a small quantity of water.

Johnson Spring, 2 miles north from Lange Spring, is located immediately upstream from intersecting shear zones which probably act as a barrier to the movement of water down the dip of the volcanic members and cause overflow into the wash. The flow from the compound spring system was about 50 gallons a minute on April 13, 1943. However, a collection system known as Johnson no. 1 has been constructed here by the Kingman Water Company and some water is transported into town through a 4-inch pipe. The total flow of Johnson Spring is about 100 gallons a minute.

It is of interest to note that two small springs occur on the hillside south of Johnson Wash downstream from Johnson Spring. A line projected N. 20° E. from Beale Spring passes close to these two small springs and intersects Johnson Wash just downstream from Johnson Spring; this linear spring pattern suggests a regional continuation of the shear zone offsetting the Beale Spring fault at Beale Spring.

The Kingman Water Company has three more collecting shafts, with subsidiary drifts, located about 0.8 mile, 1.1 miles, and 1.3 miles upstream from Johnson Spring; these collection works are numbered Johnson no. 2, Johnson no. 3, and Johnson no. 4, respectively. Johnson no. 3 is a shaft about 20 feet deep in the creek 200 feet downstream from Post well 2. This collecting shaft has dried up during the recent pumping of well 2. Johnson no. 4 is a shaft about 1,200 feet upstream from Post well 2. The Kingman Water Company reportedly currently extracts about 80 gallons a minute from this shaft by gravity flow; the yield has not been

affected by pumping of well 2. This collecting shaft is located at the site of a spring alongside an old Indian camp. Use of the collection works has dried up the spring.

Post well 1 was drilled about 0.9 mile upstream from well 2 and about 0.7 mile upstream from Johnson no. 4. About 60 feet northwest of well 1 is a capped 10-inch casing, reported to be a 275-foot well drilled by the Kingman Water Company in January 1943 but never tested. Static water level in this well was 42.29 feet below top of casing on April 13, 1943; well 1 had not been pumped for several weeks at the time this measurement was made.

Summarizing the hydrologic conditions, it is believed that all of the springs except Grapevine probably rise from the damming action of impervious or semi-impervious shear or fault zones which cross-cut the prevailing structure and interrupt the general southeasterly movement of the ground water down the dip of the pervious lava members. Thus, a number of smaller ground-water sub-basins exist within the 10-square-mile area of volcanic rocks lying north of the Beale Spring fault. It is believed that the Beale Spring fault is an effective barrier to ground-water movement and that the volcanic rocks south of this fault form an independent ground-water basin which probably is also divided into sub-basins by cementation of fault and shear zones. The Kingman Water Company has two wells in Kingman south of the Beale Spring fault. These wells are reportedly 220 feet deep, and static water levels of 90 and 104 feet below land surface were reported in April 1941, indicating that the water level at Kingman is from 150 to 200 feet lower than at Beale Spring.

Recommendations:

1. General:-Certain well sites are selected under items 2, 3, and 8. Because of the hydrologic character of the water-bearing deposits and also because no good well logs have been obtained in this area to date, the following important recommendations are made: (1) careful inspection, sampling, and logging of the formation should be carried on during drilling of any wells; (2) a careful record of drilling progress and water-level changes should be prepared; (3) drilling of any well or test hole should be stopped immediately if the Pre-Cambrian gneiss or schist is encountered, as this material will yield only small quantities of water; (4) in drilling a deep hole, if the water-bearing character of the materials penetrated is doubtful, drilling should be stopped at intervals and the open hole tested, if feasible, to determine the yield of the formation; (5) the well should be carefully test pumped after completion to determine the optimum pumping installation; and finally (6) careful and continuous operating records should be maintained, showing for each well the period of operation, quantity pumped, static level, and pumping level. If these records are kept systematically, any future development that might prove necessary could be planned and executed with a background of hydrologic performance data that would prove how much the sub-basins may be interconnected and how additional withdrawals might be made most economically and efficiently.

2. Post well 3 should be drilled in Johnson Wash at a location about 500 feet upstream from Johnson Spring. A tentative well site has been selected on the west bank of the wash, on the stream terrace about 7 feet above the bottom of the channel, about 300 feet from the pipe line

to Post wells 1 and 2, and about 0.25 mile upstream from the pressure break in this pipe line. This well should be drilled to at least 600 feet if still in volcanic rocks at this depth. It appears advisable to case the well to a depth of 400 feet; the need for casing below this depth will depend on the character of the formation encountered. Thus, the immediate economic value of a logging record is apparent.

Production from this well will probably decrease the flow of Johnson Spring.

3. Post well 4 should be drilled near the 400,000-gallon storage reservoir located on the saddle east of Johnson Wash. A tentative location has been selected 140 feet S. 70° E. of the tank and 90 feet from the pipe line. This well should be drilled to at least 700 feet unless the Pre-Cambrian is encountered. The final depth will depend in part on results of drilling Post well 3, and also on the character of materials encountered in drilling Post well 4. If the regional dip of the Pre-Cambrian contact is assumed to be 5° southeast, the base of the volcanics would be encountered at about 1,000 feet below land surface. However, this contact is probably a rough surface and may have been considerably warped previous to or during eruption of the volcanic deposits, therefore its position is uncertain. This well should be cased to about 400 feet if it proves productive; again, the need for casing below this depth will depend upon the character of the material encountered.

4. Deepen Post well 2 to about 400 feet unless Pre-Cambrian is encountered; at least the upper 200 feet should be cased.

5. There should be no additional deepening or improvement of Post well 1. It lies about 0.25 mile south of the surface contact of the

Pre-Cambrian and the volcanics and probably has penetrated essentially the entire volcanic section at that point. Furthermore, the area of exposed volcanic rocks upstream from this well is small, hence recharge opportunity is small, and current drop in water level at this well indicates rapid depletion of stored supply.

6. No test drilling in the alluvium of Hualpai Valley appears to be warranted. Past results in this valley and records from Big Sandy Valley to the south strongly suggest that yield from a well even 1,000 feet or more in depth would be small.

Possible additional developments - dependent in part on production from wells 3 and 4:

7. Test the Grapevine Springs well with a test-pumping period of several days, diverting the water by pipe line to the south of the Beale Spring fault, so that it can be determined if pumping this well has any immediate effect on Beale Spring.

8. Drill Beale Spring prospect well, at a location about 400 feet northwest of the cattle-guard and 60 feet north of the road to Grapevine Spring. This site has been marked in the field by a 2-foot square of small rocks. The well should be drilled to about 600 feet if the Pre-Cambrian has not been encountered. The top 300 to 400 feet should be cased if the well is productive. A well at this location about 500 feet northwest of Beale Spring would probably have an immediate effect on the flow of Beale Spring and might dry it up completely if heavily pumped.

Respectfully submitted,

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Engineer

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Associate Geologist

Pumping test and yield figures for Post wells 1 and 2 supplying A. A. F. Flexible Gunnery School near Kingman, Arizona

| Date | Post well 1 | | | | Post well 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Static level, feet | Yield gals. a minute | Pumping level, feet | Spec. Capacity g/ft. dd. | Static level, feet | Yield gals. a minute | Pumping level, feet | Spec. Capacity g/ft. dd. |
| June 1941[a] | 8 | 400 | 25 | 23.5 | 0 | 400 | 3 | 133 |
| Aug. 25/42[b] | 12 | 168 | 20 | 21.0 | 11.6 | 152 | 12.0 | 380 |
| | 12 | 352 | 40 | 12.6 | | 352 | 14.0 | 147 |
| | 12 | 534 | 63 | 10.5 | | 534 | 18.0 | 83.4 |
| Feb. 28/43 | 40 | 300 | 65 | 12.0 | 25 | 300 | 40 | 20 |
| Apr. 15/43 | 40 | 250 | 47 | 35.7[c] | 50 | 250 | 61 | 22.7[d] |

a. Kingman Water Company test, 8 hours, June 1941.

b. Official test, U. S. E. D. 8 hours, Aug. 25, 26, 1942, before placing wells on production.

c. Well 1 pumped on April 15 after 2 to 3 weeks shutdown, figures are for 2d hour pumping.

d. Well 2 pumped about 16 hours each day for past 2 to 3 weeks.

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